Value Consequences of Corporate Environmental Innovation

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Abstract

Relying on a new patent classification scheme of the European Patent Office (EPO), this study explores the value consequences of corporate environmental innovations. The sample consists of a large panel of international firms and spans the 1999-2015 period. As opposed to so-called off-the-shelf responses to institutional demand for corporate environmental sustainability, firms may respond by engaging in environmental innovation. However, this latter strategic choice is associated with more risk as it entails committing corporate resources for a longer horizon. What is more, theory suggests that the economic payoffs of environmental innovation are highly ambiguous. Given the peculiarities of environmental innovation, we hypothesize a non-monotonic relationship between corporate environmental innovation and capital market valuations. Correcting for self-selection bias, Fama and MacBeth (1973) regressions yield coefficient estimates that are consistent with this prediction. Specifically, we provide evidence of a U-shaped relationship between a firm's environmental innovation and its one-year-ahead market valuation. However, this average estimate conceals the presence of large cross-regional heterogeneity. Indeed, while North-American companies do show such a U-shaped relationship, the relationship of environmental innovation by European and Japanese firms and future valuation is better characterized by three regimes (+, −, +). Clearly, these results are new and bear important implications for investors, innovating firms, and policymakers as well. Rather than brutally imposing the transition across regimes, as the case so far, we eventually resort to the panel smooth transition regression (PSTR) framework which can flexibly determine the speed (brutal vs. smooth) of the transition. Reassuringly, the estimated PSTR models clearly reject the null hypothesis of a linear or homogenous relationship and provide evidence of a smooth transition.

Keywords: Environmental innovation; Stock returns; Market valuation; Green investing; Panel smooth transition regression.

JEL classification: G11, G12, O30, Q56

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1 Introduction

Firms around the globe have been facing massive consumer and activist pressure with regards to, among others, emissions to air and water, protection of bio-diversity, and stakeholder engagement (e.g. Hart, 1995). We also witness increased consumers' willingness-to pay for environmentally-friendly products and financial assets (Brown and Dacin, 1997; Roe *et al.*, 2001; Riedl and Smeets, 2017; Gutsche and Ziegler, 2019). Likewise, there has been an ever increasing investor demand for considering environmental, social and governance (ESG) criteria in investment and security analysis (Amel-Zadeh and Serafeim, 2018). Recently, twelve investor and shareholder advocacy groups have called on BlackRock to improve its climate-related shareholder resolutions and engagements by closing the gap between rhetoric and reality on climate action.[1] What is more, policymakers and academics alike exhibit renewed interest in identifying policies, laws, and institutions to effectively mitigate the risks of climate change and refocus research and development (R&D) endeavors toward environment-related projects (e.g. European Commission, 2010; Berrone *et al.*, 2013; Calel and Dechezlepretre, 2016; Angelucci *et al.*, 2018). Despite institutional (regulatory and normative) pressures and cognitive processes (Scott, 1995; Schilke, 2018) the rate of diffusion of environment-related innovation among public firms remains remarkably low (e.g. Berrone *et al.*, 2013; Whiteman *et al.*, 2013).

Amid heightened scrutiny for environmental wrongdoing, companies might respond in two ways. One possible response is the adoption of off-the-shelf environmental practices that can be obtained in the open market and that are directed at meeting minimal environmental standards (Berrone and Gomez-Mejia, 2009). Such solutions are termed end-of-pipe solutions and include recycling, treatment and recovery. Alternatively, in their quest for societal legitimacy firms can respond to these mounting pressures by embracing environmental innovation which emphasizes pollution prevention (Sarkis and Cordeiro, 2001; Berrone *et al.*, 2013). Environmental innovation can be perceived as a "behavioral indicator that the firm is trying to meet or exceed environmental performance standards concerning the invention of new designs, and the creation of novel products and processes to reduce or eliminate the use and generation of hazardous substances" (Berrone *et al.*, 2013:894).

While there is wide consensus on the social value of environmental innovations, we know remarkably little about their value consequences (Berrone *et al.*, 2013). Nor do we know much about the nature of the financial market payoffs to sustainable and responsible investing (e.g. Telle, 2006). This is all the more so that theory provides ambiguous predictions for whether environmental innovation is desirable for firm value and investors. Does the market assign higher valuations to firms that have better environmental sustainability reputations than those that do not? Alternatively, are those firms that go more green penalized by higher risk premiums, or do they expect to earn some benefits from a better environmental sustainability reputation? Can climate change mitigation technologies (CCMT) innovations (see Angelucci *et al.*, 2018) act as a (potentially undervalued) "competitive moat" for the innovating firms? Given that theory provides ambiguous predictions regarding the valuation implication of corporate sustainability, we argue that there is cause for concern to impose linearity in the CCMT inventions-valuation relationship.

This study relies on a new patent classification scheme of the European Patent Office (EPO) to provide answers to these and related questions using portfolio analyses, Fama and MacBeth (1973) regressions, and a panel smooth transition regression (PSTR) framework (see e.g. Gonzalez *et al.*, 2005; Fouquau *et al.*, 2008). The underlying identifying

[1] Source: https://www.irmagazine.com/buy-side/blackrock-urged-close-gap-between-rhetoric-and-reality-climate-action? (Accessed 13 March 2019).

assumption is that the relationship between our measure of sustainability stems from the relationship between that measure and future realized operating performance, and market efficiency in examining this relationship. However, firms may prefer trade secrets to patent applications, which results in "missing not at random problem". Therefore, we control for this endogenous sample selection in our main estimations.

Results of portfolio tests and Fama and MacBeth (1973) regressions based on a large sample of international firms that held at least one patent approved by the EPO over the 1999-2015 period suggest that the relationship between corporate environmental sustainability and capital market performance is likely non-monotonic. The observed non-linearity attests to the mixed results in the existing empirical work that has predominantly imposed linearity. Capitalizing on the power of the PSTR, we are able to flexibly elucidate conditions under which firms are rewarded in the marketplace for externally negotiating a reputation of being concerned about environmental sustainability.

This study substantively adds to the literature in three ways. First, it runs counter to the dominant assumption of linearity and coefficient stability underlying most prior studies that investigate the relationship between corporate environmental sustainability and financial performance. To that extent, our study makes some initial progress toward disentangling the definition domains of theories put forward to explain the consequences of sustainability for firm financial performance. Second, we focus on a specific measure of environmental processes (rather than an outcome measure such as emissions) aimed at corporate environmental sustainability: the proportion of sustainable technologies (so-called climate change mitigation technologies; hereafter, CCMT[2]) in a firm's patent portfolio.

Third, our study extends the existing literature by exploring how firms should incorporate environmental concerns into strategic decision making, especially because research so far has neglected how moving to a sustainable development model will affect firm competitiveness (Berrone and Gomez-Mejia, 2009; Berrone *et al.*, 2013). From a natural-resource-based view perspective, proactive environmental strategies are associated with the emergence of unique competitively valuable organizational capabilities (Hart, 1995; Sharma and Vredenburg, 1998), but they also entail organizational inefficiencies. It stands reasonable to argue that the low propensity of firms to embrace environmental innovation is attributable to the seemingly inhospitable economic logic.

2 Related Work and Hypothesis Development

This study examines the value consequences of corporate environmentally sustainable innovations. We construe corporate environmental innovation as a "behavioral indicator that the firm is trying to meet or exceed environmental performance standards concerning the invention of new designs, and the creation of novel products and processes to reduce or eliminate the use and generation of hazardous substances" (Berrone *et al.*, 2013:894).[3] In order to respond to environmental pressures, firms might resort to two[4] alternative strategies: they may either resort to so-called off-the-shelf symbolic or ceremonial efforts (also

[2]Climate change mitigation technologies aim at "controlling, reducing or preventing the anthropogenic emissions of greenhouse gases, as covered by the Kyoto Protocol" (EPO, 2016). URL: https://www.epo.org/news-issues/technology/sustainable-technologies.html (Accessed 9 March 2019).

[3]Rennings (2000: 322) defines environmental innovations as measures of relevant actors (firms, . . ., private households), which: (i) develop new ideas, behaviour, products and processes, apply or introduce them, and; (ii) contribute to a reduction of environmental burdens or to ecologically specified sustainability targets". See also Wagner (2007).

[4]See also Aragón-Correa (1998). Although firms may decide to resist rather than giving in to environmental demands, e.g. depending on the organizational identity processes at work (Schilke, 2018), we assume that firms decide to cope with those demands. Indeed, we explicitly admit that firms do not simply succumb to external pressures unreflectedly, rather they exert considerable discretion in responding to them. Also, Klassen and Whybark (1999) distinguish pollution prevenetion approaches, management systems, and pollution control approaches.

known as "end-of-pipe solutions") or simply choose to embrace environmental innovation. While end-of-pipe solutions follow a risk management logic (e.g. Fernando *et al.*, 2017), the strategic choice of environmental innovation is not only riskier (e.g. Markman *et al.*, 2004; Hyatt and Berente, 2017), but it also requires greater financial commitment, and usually bears fruit only in the long term. By contrast, environmental innovations signal a firm's quasi-irreversible (and thus credible) commitment to reduce emissions, and offer a more substantive response to environmental demands. By contributing to creating a cleaner and safer world, firms that embrace environmental innovation can achieve/enhance their environmental legitimacy over time.

A recent strand of research draws on institutional theory and innovation literature to elucidate the large variation across firms of the propensity to engage in environmental innovation, and the conditions under which firms would embrace this type of innovation (e.g. Berrone *et al.*, 2013). However, research so far has emphasized (and reached wide consensus about) the social value of environmental innovations, while neglecting efficiency issues and the impact of such strategic choices on firm performance. Berrone and Gomez-Mejia (2009) attribute this neglect to financial considerations not being the primary driver of socially-compliant management practices. Some researchers draw on institutional logic to argue that "green investments" cannot be financially justified, at least in the short-run (e.g. Sarkis and Cordeiro, 2001; Sadovnikova and Pujari, 2017; Berrone *et al.*, 2013, Bansal, 2005; Bansal and Clelland, 2004; Delmas, 2002; Hoffman, 1999). It appears that the value consequences of environmental innovations are markedly ambiguous. If anything, institutionalist studies tend to paint environmental innovation as an economically nonviable option to cope with external environmental pressures. The fly in the ointment is that firms typically show differential responses to similar institutional pressures (Oliver, 1991, 1997), thereby giving rise to the potential of heterogeneous competitiveness effects of corporate environmental innovation. This "within-field heterogeneity" (Schilke, 2018) is due to the fact that firms may not experience or make sense of these external pressures in the same way.

Does corporate environmental innovation have no salutary effect on firm performance, as suggests institutional theory-based research? At least from a natural-resource-based view (NRBV) perspective, one may cast doubt on the institutionalist premise to the extent that NRBV posits that proactive environmental strategies[5] are associated with the emergence of unique competitively valuable organizational capabilities (Hart, 1995; Sharma and Vredenburg, 1998). If true, it is then questionable why the degree of corporate environmental innovation remains limited (Stucki, 2019; Longoni and Cagliano, 2018). In other words, can the relatively low diffusion of environment-related innovations be considered as evidence that companies systematically overlook profitable opportunities (Majumdar and Marcus, 2001)? Using citations to a firm's environmental patents as measure of environmental innovation, Berrone *et al.* (2013) find that larger firms, firms with higher research and development (R&D) intensity, firms with more emissions with respect to their industry peers (deficiency gap), and firms with more specific assets generate more environmental innovations. But, are they economically worth it?

There are two opposing theories in this regard (Ba *et al.*, 2013). Proponents of the negative view include Vance (1975), Portney (1994), and Walley and Whitehead (1994). In turn, defenders of the positive thesis include Klassen and McLaughlin (1996), Hart (1995), Aragón-Correa and Sharma (2003), and Teo *et al.* (2017). The latter group of researchers maintain that corporate proactive environmentalism should develop capabilities from which firms can derive a competitive edge over their competitors in terms of lower costs, improved environmental legitimacy, and strategic alignment with future changes in the general business conditions (see also Stucki, 2019). Hart and Ahuja (1996) provide empirical evidence

[5] In this study, we consider corporate environmental innovation as an indicator of proactive corporate environmentalism.

that it pays to reducing pollution and emissions, while Konar and Cohen (2001) consider corporate environmental performance as positive signals that get rewarded by the stock market.

Despite the large body of research (see e.g. Ambec and Lanoie, 2008, for a review), theory hardly makes unambiguous predictions about the conditions under which corporate environmental innovation may serve as a resource for enhancing competitiveness (Berchicci and King, 2007). There are reasons why corporate environmental innovation should enhance the competitiveness of the innovating firm: lower costs (Majumdar and Marcus, 2001; King and Lenox, 2002) and increased revenues (e.g. Ambec and Lanoie, 2008) due to increasing environment consciousness and willingness to pay for environment-friendly products and services. Stucki (2019) finds that firms with the highest energy costs stand to gain from investments in green technologies, while there is a negative impact on the productivity of firms with low energy costs and no impact for those with medium energy costs.

In rebuttal, Fernando *et al.* (2017) argue, and empirically demonstrate, that corporate environmental policies that are directed at enhancing the firm's perceived environmental friendliness ("greenness"), of which corporate environmental innovation is a striking example, shy away from green firms.

The related empirical evidence is mixed. For example and in a German context, Hottenrott et al. (2016) find that mere adoption of green technologies is associated with lower productivity, while the adoption of green technologies alongside changes in organizational structures has no impact on productivity. See also The study by Ba *et al.* (2013), based on 261 events relative to 14 companies trading in Germany, US, Japan, Korea and France, is the first to document a positive stock market reaction to automakers' announcements of green technology and vehicle innovation. Their sample relies on very large multinational companies and they focus on short-term impact.However, Vastola *et al.* (2017) argue that the mixed empirical evidence stems from the neglect thus far of such contingencies as the cultural setting or the normative regime in which the firms operate. In turn, Stucki (2019) explains the absence of unanimity in this research by the neglect of the moderating role of energy costs. However, Khuntia *et al.* (2018) bridge NRBV and signaling theory and find that the positive relationship between green IT[6] investment with a higher profit is partially *mediated* by a reduction in IT equipment energy consumption.

Given the ambiguity of the theoretical prediction as to the value consequences of corporate environmental innovation, and extrapolating from existing empirical evidence, we hypothesize a non-monotonic relationship between a firm's environmental innovative endeavor and its future market valuations. We contribute to the debate related to when it pays to be green (King and Lenox, 2001; King and Lenox, 2002; Stucki, 2019) with a focus on innovations in the field of climate change mitigation technologies in an international setting. Stucki (2019) uses cross-sectional survey data (year: 2014) pertaining to Germany, Switzerland and Austria. Instead, we use panel data in an international setting with a better proxy for corporate environmental innovation. He calls for more studies about other types of green technologies and an extension to other countries.

3 Data and Methods

3.1 Sample and Data

The sample consists of 3,281 firms listed in 38 countries, and that held at least one patent approved by the EPO over the period 1999-2015. The firms are grouped in fifteen sectors,

[6]That is, information and communication technologies that can reduce the adverse environmental impacts of business activities.

and nested within three main geographical areas: U.S., Europe, and Japan. The advantage of using patents granted by a single patent office mitigates any variations in patent grant practices across jurisdictions, thereby increasing comparability across countries and over time. Although the sample covers a large number of firms, not all firms have data throughout the sample period. The sample firms are required to have accounting and trading data for at least three years, and non-negative book equity values. In addition, because the sample includes both active and dead firms (15.2%), survivorship bias does not appear to be a concern. Company-specific measures of patent attributes are derived from proprietary raw data obtained from a Germany-based Management firm. Capital market and accounting data are from Thomson Reuters Datastream and Wharton Research Data Services (WRDS), while data on analysts and ESG factors are collected from I/B/E/S, and ASSET4, respectively.

In previous studies, environmental innovation has been commonly measured through questionnaire surveys (e.g. Anton *et al.*, 2004, Christmann, 2000) or winning environmental awards (e.g. Klassen and McLaughlin, 1996; Dangelico and Pujari 2010; Vastola *et al.* (2017) provide sundry approaches to the operationalization of environmental innovation, see their Table 1). However, this research design offers little insights into environmental innovation *per se*, and responses to these questionnaires may be seriously biased (Berrone *et al.*, 2013). Another set of studies have relied on the adoption of environmental management systems, which by nature tend to be standardized and emphasize more uniform solutions to environmental concerns. Instead, we follow prior research (e.g. Brunnermeier and Cohen, 2003) and measure environmental innovation through successful environmental patent applications granted to the industry, which can be considered "a much more robust indicator of environmental innovation" (Berrone *et al.*, 2013:898). This argument roots on the requirement of novelty and non-obviousness for inventions to patented, the temporal monopoly rents to the patentee, and the public availability of detailed information about the patented inventions. In particular, we resort to patents classified as *Y02* by the EPO (see also Calel and Dechezlepretre, 2016).

We primarily measure corporate environmental innovation by the the ratio of citations-weighted CCMT patent count. Because we are interested not in the generalized perception of a firm's environmental innovation but rather in its relative position in the industry of interest in a tiered hierarchy, we rely on fractional ranks that control for the skewed distribution of environmental innovation counts, and ensure that the median firm in each industry and in each year and in each region gets a ranking of 0.5. So the ensuing scores range from 0 (lowest propensity to engage in environmental innovation) and 1 (highest propensity to engage in environmental innovation). This transformation ensures that we account for heterogeneity across industries and regions event though trends are less captured by such transformation (but trend can be captured by from using changes in the computed industry-year-region fractional ranks).

While we use the fractional rank version of the measure as our primary measure of environmental innovation, we do use two alternative measures: the natural log of one plus the ratio of citations-weighted CCMT patent count and the plain ratio of citations-weighted CCMT patent count.Turning onto the controls, we use the natural log of the ratio of the book value of property, plant, and equipment (PPE) over full-time employees (FTE) to proxy for asset specificity (see Ziedonis, 2004). In turn, we use the log of the ratio of working capital to sales to proxy for organizational slack.

3.2 Research Design

The empirical tests proceed in three stages. The first stage conducts portfolio analysis to explore the relationship between corporate environmental innovation and stock returns. In the second stage, we examine the direct contribution of the the environmental innovation of a focal firm to its future market valuations via annual Fama and MacBeth (1973) cross-sectional regressions, allowing for a flexible functional form by including higher-order terms in our measure of corporate environmental innovation and correcting for self-selectivity (Heckman 1976, 1979). Here, we first fit a probit model of the likelihood of a firm to engage in patented environmental innovation and then perform Fama and MacBeth (1973) regressions in which we include the control function obtained from the estimated probit function to correct for selection effects. All these specification control for region, industry, and year fixed effects. The lack of theory to predict the exact functional form of the relationship between corporate environmental innovation and future market valuations commands the use of the PSTR framework to flexibly determine the thresholds and the various regimes involved in the relationship we are after.

By including industry- and country-level fixed effects, our identification strategy exploits within-industry and within-region variations to estimate the relationship between environmental innovation and future market valuations. We also control for the effect of the firm's affinity to CCMT by including region-level dummies (the results are insensitive to including country-level fixed effects, availbale upon request).

4 Results

4.1 Summary Statistics

Table 1 provides sample descriptive statistics. The average (median) firm has 30 (1) patents related to climate change mitigation technologies. What is more, the average (median) ratio of environmental patents over the overall patent count of the sample firms is 5.2% (0.95%). It appears that there is great variation in the degree to which the sample firms engage in patented environmental innovation. Similarly, the sample mean (median) overall patent count lies by 473 (67). This skewed distribution of patent count variables has led us to transform our measure of environmental innovation, *Y02*, into industry-region-year fractional ranks, which range from 0 (for firms with the least green patent portfolios) to 1 (for firms with the most green patent portfolios). In turn, the average (median) market-to-book ratio levels out at 2.82 (1.69), while the mean (median) firm has a market value of €6.60 billion (€0.95 billion) and the standard deviation is €22.14 billion.

The data also indicate that there is large cross-regional variation in most of the variables of interest. For example, the sample average ratio of environmental patents in the entire patent portfolio of the sample firms in Japan, Europe, and North-America (including US and Canada) is 5.56%, 5.96%, and 4.25%, respectively. The corresponding median values are 2.13%, 0.74%, and 0%, respectively. The evidence in this study of low diffusion of CCMT innovation comport with findings in related recent work (e.g. Stucki, 2019). Finally, firms are, on average, relatively larger in the U.S. (€9.31 billion) and Europe (€9.1 billion) than in Japan (€2.7 billion).

4.2 Portfolio Tests

We examine the relationship between our measure of environmental innovation and future stock returns by tracking the one-year-ahead stock market performance of firms that exhibit quite homogeneous characteristics in terms of patented innovations on climate change mitigation technologies (CCMT). The investment horizon spans the period from 1 July 1999 to 31 December 2015. Consistent with prior research (e.g. Edmans 2011), we use investment signals of 31 December of year t-1 for the investment period spanning the period from 1 July t to 30 June t+1. The portfolios are formed based on quintiles in the distribution of our measure of environmental innovation, allowing firms to migrate across portfolios on a yearly basis. We require firms to exhibit at least one patented innovation on CCMT for them to be included in the quintile portfolios P1 to P5. In rebuttal, firms with no entry of patented innovation on CCMT in a given year are regrouped into a portfolio we label P0. The transition probability matrix provided in Online Appendix B suggests that there is large variation in *Y02* to allow identification of the effect of interest. We rely on weekly data to compute value-weighted one-year-ahead returns on the various portfolios.

Panel 2 of Table 2 shows the results of the portfolio tests. These results indicate that the average annualized excess returns on the Y02-based portfolios P0 through P5 level out at 9.86%, 4.54%, 4.69%, 6.38%, 5.93%, and 4.69%, respectively. In turn, the associated annualized standard deviations range from 15.58% (P2) to 19.46% (P3). We observe an abrupt decrease in the average excess returns of about 53% when moving from P0 to P1. The Sharpe ratio of P0 is 0.58, while the Sharpe ratios of the portfolios P1 through P5 range from 0.26 (P5) to 0.33 (P3). It appears that the ratio of a firm's patented innovations on CCMT likely shares a non-monotonic relationship with one-year-ahead stock returns. Indeed, univariate tests in Panel B of Table 2 (comparing the portfolio of firms with no patented innovation on CCMT (P0) to portfolios of firms that have at least one CCMT patent in a given year) indicate that P0 significantly outperforms P1 and P2. The excess returns on P0 are not significantly different from those on P3, P4,and P5. Notwithstanding, tests of equality of medians in Table (see panel B) also attest to significant differences of median returns between P0 and each of the portfolios P1 through P5. Yet, the level statistical significance varies across portfolios.

It is unclear whether the apparent out-performance of P0 documented above is not attributable to non-modeled risk. To address this concern, we regress the monthly excess returns of each test portfolio on a number of pricing/mispricing factors generally used in the empirical asset pricing literature. Specifically, our main tests are based on the Fama and French (1993) three factors augmented by Carhart (1997)'s momentum factor. The results reported in Panel A of Table 3 indicate that only P0 exhibits a positive and significant abnormal return (alpha). By contrast, while P1 through P5 consistently show negative alphas, only the alpha of P1 turns out to be statistically significant at the 5% level. Based on these findings, the annualized abnormal returns associated with P0 and to P1 level out at 3.67% and -1.79%, respectively, implying that P0 is undervalued while P1 is overvalued. The differential abnormal returns amounts to 5.5% and is not only statistically significant but also economically meaningful. To put these figures in perspective, we recall that the returns on major stock indices are well-below this differential abnormal return. For example the average annualized returns on the S&P 500 level out at 3.23% against 1.01% for the STOXX Europe 600 Index, and 1.76% for the Nikkei 225 Stock Average Index.

A closer inspection of Panel A of Table 3 allows the conclusion that larger firms are more likely to be included in P1 and P2, while smaller firms show a higher propensity to be included in the portfolios P0, P4, and P5. P3 and P4 are populated by mid-cap firms. Panel B of Table 3 suggests that this evidence is robust to using the Fama and French (2015) five pricing factors[7] in conjunction with the financing-based misvaluation factor proposed by Hirshleifer and Jiang (2010). If anything, the results even gain in statistical power.

The evidence gleaned from our portfolio tests implies that embracing environmental innovation might on average be associated with a subsequent valuation discount. However, portfolio tests are unable to identify the economic mechanisms underlying the documented valuation discount associated with patented innovations on CCMT. As a result, we resort to Fama and MacBeth (1973) regressions

[7]Fama and French(2017:441) argue that a "five-factor model that adds profitability and investment factors to the three-factor model of Fama and French (1993) largely absorbs the patterns in average returns".

4.3 Multivariate Analysis

Estimates based on ordinary least squares (OLS) regressions might be biased given that our setting is potentially subject to sample selection bias. Owing to idiosyncrasies of environmental innovation, firms may strategically choose to engage in or to abstain from environmental innovation, and instead adopt so-called end-of-pipe environmental solutions or simply acquiesce to ensuing external sanctions. Whether a firm engages in environmental innovation search and successfully patents this invention (the sample selection rule) determines the availability of data. If we construe environmental innovation as a "behavioral indicator that the firm is trying to meet or exceed environmental performance standards" (Berrone *et al.*, 2013:894), then it becomes obvious that our study uses a non-randomly selected sample of innovating firms. In addition, extant research suggests that institutional pressures play a role in inducing environmental innovation, but that role is moderated by firm-specific observed and unobserved characteristics (see e.g. Berrone *et al.*, 2013).

Therefore, we adopt the Heckman (1976, 1979) two-stage estimator to correct for sample-induced endogeneity (Certo *et al.*, 2016). Specifically, we included a vector of predictors drawn from prior studies, as well as sector and country fixed effects in the first stage probit model for predicting the likelihood of being granted at least one environment-related (i.e. CCMT) patent by the European Patent Office (EPO) in the next year. To that extent, the dependent variable is a one-year-ahead indicator variable that takes the value of 1 if the firm is granted a CCMT patent in the next year, and 0 else. We obtained the inverse Mills ratio (IMR) from the first-stage estimation, and used it as a control in the second stage model via theFama and MacBeth (1973) two-step procedure for predicting the stock market valuation implications of patented environmental innovation.

In our Heckman two-stage procedure, we use one-year-lagged peer R&D capital and peer total patent count of environmental innovation as appropriate exclusion restrictions because these variables affect the likelihood of firms' propensity to engage in patented environmental innovation (e.g. Leary and Roberts, 2014; Foucault and Fresard, 2014; Basse Mama, 2017), but their impact on market valuation of a focal firm is undetermined. The results of the first-stage regressions are reported in Table 4, while those pertaining to the second-stage regressions are shown in Table 5.

First-stage:

Controlling for year, industry and country fixed effects, our selection model indicates that only one of our two instruments, namely the one-year-lagged peer R&D capital, loads significantly and positively so on the future environmental innovation patenting activity of a focal firm. Table 4 also indicates that firm size, as measured by its total assets shares a U-shaped relationship with the likelihood of engaging in environmental innovation in the next year. In contrast, there is an inverted U-shaped relationship between R&D intensity and the future probability of being granted a environment-related patent (see also Ugur et al. 2016, for similar inferences related to firm survival). In addition, innovative efficiency (PRDC) is negatively related to future patented environmental innovation, implying that firms with higher degrees of innovative efficiency, in terms of number of patents per unit of R&D capital, are less likely to engage in patented environmental innovation. However, consistent with Berrone *et al.* (2013), we find that the general ability of firms to patent (measured by the log of patent count) loads positively and significantly on future patented environmental innovation.

What is more, we find that firms are less likely to engage in environmental innovation when they have sufficient slack in internal resources. This result is counter-intuitive because organizational slack provides firms with more flexibility and should, all else equal,enhance their propensity to more decisively experiment with high risk innovation projects and tolerate failure (Chattopadhyay *et al.*, 2001). In fact, slack in organizational resources would act like a cushion against short-term oriented corporate behavior, which is highly important for environmental innovation. In rebuttal, the average sample firms is more likely to do so when it is heavily invested in firm-specific assets. Williamson (1985) argues that this negative loading is attributable to the lower ability of such firms to redeploy specialized assets in case of default or liquidation (see also Ziedonis, 2004). Firms might use environmental innovation as a strategic shield to safeguard their assets from losses. We interpret these results to mean that firms with sufficient slack may prefer to engage in so-called symbolic responses to external demand for environmental sustainability rather than engaging in risky environmental innovation with long-term horizon and ambiguous economic payoffs. Alternatively, firms with sufficient slack would tend to use slack as a sandbag against any external regulatory and normative pressures.

Second-stage:

Table 5 shows the results from our second-stage estimation, and is divided into two parts: columns 1-4 relate to variants of the Heckman (1976, 1979) models, while column 5 shows results from ordinary least squares (OLS) which are contrasted in particular to column 2 of Table 5. In the second-stage, we rely on the Fama and MacBeth (1973) two-step approach to estimate our model, and test the significance of estimates using the Newey and West (1987) procedure that is robust to heteroskedasticity and auto-correlation (lag length: 5). The Fama and MacBeth (1973) two-step procedure has been widely used in prior study that examine the market value implications of innovation variables (e.g. Hirshleifer *et al.*, 2017; Basse Mama, 2018).

As a sniff-test of self-selectivity, we observe that the coefficient on the selection variable, IMR, is negative and significant at the 1% level (see columns 1-4 of Table 5), implying that the error terms in the first-stage estimation and in second-stage stage have a negative correlation. To that extent, factors that make environmental innovation patenting activity more likely also tend to be associated with lower future market valuations. Our results also attest to both the relevance and validity of lagged peer R&D capital used to instrument firm's decision to engage in patented environmental innovation (see e.g. Certo *et al.*, 2016). On these grounds, we now turn to discussing the estimated coefficients from the various second-stage regressions in Table 5.

Column 1 of Table 5 indicates that the linear term of environment-related patents does not matter for future market valuations. Yet, when we allow for non-linearity in column 2, we observe that environmental innovation shares a U-shaped relationship with one-year-ahead market valuations. At lower levels of CCMT patent count (Y02), the valuation effect of environmental innovation is negative and highly significant, but becomes positive beyond a certain threshold. Based on our quadratic specification in column 2 of Table 5, the turning point lies in the third quintile of the sample distribution of CCMT patent counts. It should be recalled that our independent variable of interest is *Y02*, which is the industry-year-region fractional rank of a focal firm depending on the proportion of the firm's environment-related patents relative to its overall patent count. This transformation implies that our measure of environmental innovation ranges from zero to one. That is, each year, the leading firm in environmental innovation in each industry in each region (US, Japan, and Europe) receives a rating of one, and the laggard firm in each industry in each of the three regions receives a rating of zero. This transformation allows easy interpretation of the coefficient on environmental innovation, as it is the difference in future market valuation between the leader in terms of patented environmental innovation and the least forthcoming firm in the industry in a given region. When we use the natural log of one plus CCMT patent counts to proxy for environmental innovation, we continue to attest to a U-shaped relationship between environment-related patent count and one-year-ahead market valuations (see column 3 of Table 5). The same conclusion obtains in column 4, where we measure environmental innovation by simply taking the ratio of environment-related patents over total patent count of a focal firm. Besides, tests of multicollinearity following Belsley et al. (1980), indicates that the inferences are not driven by multicollinearity.

Besides, we examine whether or not the ability of firms to self-select into environment-related innovation matters. To this end, we contrast column 2 of Table 5 with column 5 of the same table. We find that the sign of the OLS coefficients on environmental-related patents is similar to to the sign of their counterparts obtained the Heckman two-stage estimator, but the coefficient estimates are consistently statistically not different from zero, implying that environment-related innovation does not matter for future market valuations. Similar inferences are drawn from an OLS estimation that includes only the linear term of the independent variable of interest in combination of the whole set of controls used so far (available upon request).

In addition, the Heckman estimator requires that the probit function be estimated in the entire sample, while the estimation of the behavioral function is performed solely on the selected sample (Heckman, 1979). Therefore, we exclude firms that have never patented environment-related innovation over the full sample period. The results hitherto of a U-shaped relationship are resilient to excluding firms that have never patented an environmental innovation over the sample (see Table Table 6). We even experiment by restricting the sample to only those firms that have, in a given year, at least one environment-related patents, and cluster the standard errors by firms and year as per Petersen (2009). While this specification change reduces the number of observations to 10,489 firm-years, we continue to observe a U-shaped relationship between environment-related patents and future market valuations. Only do the coefficients become larger: -4.42% ($p = 0.011$), and +3.01% ($p = 0.025$) for the linear term and quadratic term of our measure of environmental innovation, respectively.

Furthermore, one might argue that the non-linear relationship documented hitherto might be an artifact of country-level heterogeneity or of the presence of too many countries ($n = 38$) with differential sizes in the sample of analysis. To alleviate this concern, we restricted the sample of analysis only to countries that exhibit a sample weight of at least 1%. This restriction resulted in keeping the following countries: Canada, France, Germany, Japan, Sweden, Switzerland, the United Kingdom, and the US. These eight countries account for about 91% of the total sample of analysis. The coefficients of interest plotted in Table 7 are slightly smaller but they continue to be statistically significant at the 5% level or better for our preferred measured of environmental innovation, *Y02*. By contrast, the log measures (*lnY02*, *lnY02_sq*) and the simple ratio measures (*Y02ratio*, *Y02ratio_sq*) exhibit slightly weaker statistical power.

Next, we conduct region-specific and industry-specific analyses given that the three regions can be considered as heterogeneity not only in terms of their patenting behavior but also in their propensity to promote environment-related innovations, which molds the propensity of firms in these regions to engage in environmental innovation (e.g. Calel and Dechezlepretre, 2016). Columns 1-3 of Table 8 show the results from a regression similar to column 2 of Table 5 but includes a cubic term of our preferred measure of environmental innovation. Another difference with column 2 of Table 5 is that the estimation is run by major geographic region, with the region US including Canada in this table. By contrast, columns 4-6 of Table are the region-specific counterparts of column 2 of Table 5. We observe that non-linearity seems to prevail in all three major geographical regions (Europe, North America, and Japan) , albeit with differing number of regimes. Specifically, Europe and Japan likely have three regimes (+, −, −), while North-America (i.e US and Canada) is better characterized by two regimes (−, +). Apart from these differential shapes of the relationship between environmental innovation and future market valuation among the three major regions, it is important to point to the huge differences in the magnitudes of the coefficient estimates between Europe and Japan. The coefficient estimates for the European sub-sample are at least ten times as high as those relative to the Japanese sub-sample. It is unclear, what factors underlie the cross-regional heterogeneity documented in Table 8 (we envision pursuing this in later stages after performing the PSTR below). Finally, analyzing the value implication of environmental innovation at the industry level, we find significant U-shaped effects only for the sectors “producer manufacturing” and “energy and non-energy minerals” (available upon request).

A general caveat, however, is that we so far have (brutally) imposed these regimes as we have no a priori theory to predict the number of these regimes. Therefore, we capitalize on the statistical power of the PSTR (see e.g. Gonzalez *et al.*, 2005; Fouquau *et al.*, 2008) to flexibly elucidate conditions under which firms are rewarded in the marketplace for externally negotiating a reputation of being concerned about environmental sustainability by engaging in patented innovation con CCMT.

In the unreported results from the PSTR framework, the linearity tests clearly reject the null hypothesis of a linear or homogeneous relationship. The Lagrange Multiplier (LM) test value ranges from 167.3 to 176 in the various specifications considered. This remarkably high rejection level makes the presence of nonlinear dynamics unambiguous, and shows that the Y02 variable is an important driver. Furthermore, the estimated smooth parameter has a moderate value (5.86 or 4.50), which indicates that the transition between the two regimes is relatively smooth.

5 Conclusion

This study has examined the the value consequences of corporate environmental innovations relying on portfolio tests and Fama and MacBeth (1973) two-step approach with corrections for self-selectivity. The sample consists of more than 3,000 international firms trading in North America, Europe and Japan. Our portfolio tests suggest that the portfolio of firms with no environmental innovation in a given year outperforms portfolios of firms with environmental innovation which lies in the first two quintiles of the distribution of industry-year-region environmental innovation. What is more, our Fama and MacBeth (1973) indicate that the environmental innovation of the average sample firm shares a U-shaped relationship with one-year-ahead market valuations. This average effect conceals the presence of large cross-regional variations, with North-American firms showing a U-shaped relationship while their European and Japaneses counterparts are better characterized by cubic polynomial of the form $+$, $-$, $+$.

This study substantively adds to the literature in at least two ways. First, it runs counter to the dominant assumption of linearity and coefficient stability underlying most prior studies that investigate the relationship between corporate environmental sustainability and financial performance. The study attests to the high ambiguity inherent in engaging in corporate environmental innovations. Not only does the study provide evidence of heterogeneous effects across industries, but it also attests to the the existence of large cross-regional variations in the relationship of corporate environmental innovation and future market valuation. Second, Our measure of corporate environmental innovation is a “more robust indicator of environmental innovation” (Berrone *et al.*, 2013:898) than the ones used in prior studies. To the best of our knowledge, this study is among the first, if not the first, to explore link between environmental innovation and market valuations based on the new patent classification scheme, *Y02*, of the European Patent Office (EPO). While preliminary, the results attained in this paper are of interest to innovating firms, investors, and policymaker as well. In particular, European policymakers would have strong incentives in heeding the implication of this study.

Our finding of low economic returns to corporate environmental innovation provides weak incentives to achieve climate goals of the Paris Agreement; there should, therefore be political intervention (see e.g. Veugelers, 2012).

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Table 1: Summary Statistics

Variable	Mean	SD	Q1	Median	Q3
Y02	29.84	161.53	0	1	10
Ratio Y02 over total patent count	0.05	0.11	0	0.01	0.06
Total patent count	472.98	1625.25	19	67	279
Log market to book ratio (t+1)	0.0238	0.0732	0.0102	0.0169	0.0283
Market to book ratio	2.82	26.69	1.03	1.69	2.88
Market value	6597.94	22138.33	321.68	949.82	3566.38
Size	8.47	1.69	7.38	8.41	9.56
R&D intensity	0.45	11.37	0.01	0.03	0.08
R&D capital	0.18	0.30	0.04	0.09	0.21
Slack	1.44	43.79	0.11	0.24	0.45
Asset specificity	4.07	0.97	3.42	4.06	4.69
Age	22.82	11.66	13	23	33

Note. The number of observations is 18,954, which corresponds to observation of Table 5. However, the number of observation varies depending on the analysis being conducted.

Table 2: Portfolio Tests

Panel A: Monthly returns on the various portfolios

	Mean	**SD**	**Q1**	**Median**	**Q3**
[P0]	0.0079	0.0491	-0.0202	0.0113	0.0368
[P1]	0.0037	0.0451	-0.0234	0.0054	0.0351
[P2]	0.0038	0.0450	-0.0208	0.0084	0.0339
[P3]	0.0052	0.0562	-0.0276	0.0093	0.0395
[P4]	0.0048	0.0529	-0.0198	0.0054	0.0320
[P5]	0.0038	0.0525	-0.0291	0.0057	0.0376

Panel B: Test of equality of means and medians

	Test of equality of means			**Test of equality of medians**		
	Mean difference relative to [P0]	*t-stat.*	*p-value (two-tailed)*	Median difference relative to [P0]	*z-stat.*	*p-value (two-tailed)*
[P1]	-0.0042	3.02	<0.01	-0.0059	3.26	<0.01
[P2]	-0.0040	2.72	0.01	-0.0029	3.24	<0.01
[P3]	-0.0027	1.47	0.14	-0.0020	1.74	0.09
[P4]	-0.0031	1.51	0.13	-0.0059	1.74	0.11
[P5]	-0.0040	1.52	0.13	-0.0056	1.97	0.07

Table 3: Computing the abnormal returns (alphas)

Panel A: Tests using the Fama and French (1993) 3-factor model augmented by the momentum factor

	[0]	[1]	[2]	[3]	[4]	[5]
MRP	0.9746***	0.9387***	0.9310***	1.1538***	1.0627***	1.0128***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
SMB	0.2568***	-0.1577***	-0.1011**	-0.0596	0.1299**	0.1534*
	(0.0000)	(0.0000)	(0.0161)	(0.2704)	(0.0399)	(0.0967)
HML	-0.2839***	0.0127	0.0175	0.1607***	0.0685	0.1698**
	(0.0000)	(0.6110)	(0.6014)	(0.0002)	(0.1750)	(0.0214)
WML	-0.0135	0.0652***	0.0575**	-0.0625**	-0.0823**	0.0018
	(0.4591)	(0.0001)	(0.0104)	(0.0305)	(0.0148)	(0.9701)
Alpha	0.0030***	-0.0015**	-0.0014	-0.0012	-0.0010	-0.0026
	(0.0002)	(0.0433)	(0.1488)	(0.3533)	(0.4883)	(0.2277)
N	198	198	198	198	198	198
R-sq	0.9488	0.9491	0.908	0.9025	0.8494	0.6737

Panel B: Tests using the Fama and French (2015) five factor model augmented by the UMO factor

	[0]	[1]	[2]	[3]	[4]	[5]
MRP	0.9581***	0.9571***	0.9561***	1.1269***	1.0341***	0.9459***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
SMB	0.2940***	-0.1395***	-0.0941**	-0.0648	0.1697***	0.2603***
	(0.0000)	(0.0000)	(0.0168)	(0.2053)	(0.0036)	(0.0023)
HML	-0.1732***	-0.1501***	-0.1945***	0.3591***	0.3028***	0.5204***
	(0.0002)	(0.0006)	(0.0008)	(0.0000)	(0.0004)	(0.0000)
RMW	-0.0674*	0.0715*	-0.0041	-0.0711	-0.2887***	0.0204
	(0.0989)	(0.0578)	(0.9345)	(0.2769)	(0.0001)	(0.8522)
CMA	-0.1400**	0.1104**	0.2764***	-0.1641*	-0.0929	-0.5907***
	(0.0182)	(0.0433)	(0.0002)	(0.0839)	(0.3896)	(0.0002)
UMO	0.0314	0.0493**	0.0071	-0.0472	-0.0189	0.0766
	(0.1774)	(0.0218)	(0.8046)	(0.2054)	(0.6564)	(0.2190)
Alpha	0.0030***	-0.0016**	-0.0014	-0.0010	-0.0009	-0.0024
	(0.0001)	(0.0278)	(0.1402)	(0.4216)	(0.5295)	(0.2578)
N	198	198	198	198	198	198
R-sq	0.9515	0.9512	0.9125	0.9052	0.8614	0.6966

Table 4: First-stage estimation of the Heckman Two-stage procedure

Total Assets	-0.4650***
	(0.0074)
Total Assets square	0.9646***
	(0.0000)
R&D intensity	0.7870***
	(0.0000)
R&D intensity square	-0.7085***
	(0.0000)
Patents to market value	0.0270
	(0.7748)
Capital expenditures	0.0553
	(0.1829)
Turnover	0.0756*
	(0.0622)
Selling, general, and administrative expenses (SGA)	0.0762
	(0.1035)
Patents to R&D capital (PRDC)	-0.1718***
	(0.0067)
Log of total patent count	0.5280***
	(0.0000)
Slack	-0.2222***
	(0.0000)
Asset specificity	0.4467***
	(0.0000)
Peer R&D capital	2.1822***
	(0.0001)
Peer environmental patents	-0.0004
	(0.5448)
Constant	-3.1153***
	(0.0000)
N	21,631
Pseudo R-square	0.42
log-likelihood	-8766.65

Table 5: Second-stage estimations of the Heckman Two-stage procedure

	Heckman (second-stage estimations)				**OLS**
	(1)	(2)	(3)	(4)	(5)
Y02	-0.0009	-0.0097***			-0.0067
	(0.4041)	(0.0009)			(0.2669)
Y02 square		0.0103***			0.0092
		(0.0004)			(0.1885)
lnY02			-0.0175***		
			(0.0095)		
lnY02 square			0.0240**		
			(0.0250)		
Y02ratio				-0.0141**	
				(0.0137)	
Y02ratio square				0.0142***	
				(0.0038)	
IMR	-0.0165***	-0.0169***	-0.0160***	-0.0158***	
	(0.0003)	(0.0003)	(0.0003)	(0.0004)	
SLACK	-0.0085***	-0.0084***	-0.0089***	-0.0089***	-0.0083***
	(0.0008)	(0.0008)	(0.0005)	(0.0006)	(0.0001)
SCIENCE	0.0023**	0.0022**	0.0024**	0.0024**	0.0016
	(0.0239)	(0.0309)	(0.0239)	(0.0235)	(0.3343)
PATME	-0.0049**	-0.0053***	-0.0053**	-0.0053**	-0.0020
	(0.0153)	(0.0098)	(0.0117)	(0.0117)	(0.5299)
SIZE	-0.0012***	-0.0014***	-0.0013***	-0.0013***	-0.0007
	(0.0010)	(0.0001)	(0.0003)	(0.0003)	(0.1083)
RDS	0.0065***	0.0061***	0.0065***	0.0065***	0.0064***
	(0.0013)	(0.0020)	(0.0016)	(0.0016)	(0.0017)
CAPEX	0.0026***	0.0026***	0.0028***	0.0028***	0.0021
	(0.0077)	(0.0075)	(0.0051)	(0.0050)	(0.2703)
TURNOVER	0.0033*	0.0033*	0.0035*	0.0035*	0.0046**
	(0.0640)	(0.0639)	(0.0507)	(0.0506)	(0.0119)
SGA	-0.0224***	-0.0222***	-0.0226***	-0.0226***	-0.0207***
	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0000)
DMTB	-0.0254	-0.0254	-0.0255	-0.0255	0.0048***
	(0.5108)	(0.5109)	(0.5086)	(0.5092)	(0.0004)
1/Book Equity	0.0032**	0.0032**	0.0031**	0.0031**	0.0011***
	(0.0232)	(0.0231)	(0.0228)	(0.0227)	(0.0000)
Constant	0.0534***	0.0552***	0.0546***	0.0544***	0.0403***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
# observations	18,954	18,954	18,954	18,954	20,453
R-square	0.1717	0.1722	0.1721	0.1721	0.0416

Table 6: Restricting the sample to firms that have at least one environmental patent in the sample period

	Heckman (second-stage estimations)		
	(1)	(2)	(3)
Y02	-0.0107***		
	(0.0052)		
Y02_square	0.0116***		
	(0.0008)		
lnY02		-0.0149**	
		(0.0140)	
lnY02_sq		0.0196*	
		(0.0638)	
Y02ratio			-0.0115**
			(0.0161)
Y02ratio_sq			0.0109**
			(0.0331)
IMR	-0.0257***	-0.0245***	-0.0243***
	(0.0003)	(0.0020)	(0.0022)
SLACK	-0.0060**	-0.0065***	-0.0065***
	(0.0109)	(0.0062)	(0.0061)
SCIENCE	-0.0006	-0.0003	-0.0003
	(0.6939)	(0.8477)	(0.8484)
PATME	-0.0062*	-0.0060*	-0.0060*
	(0.0588)	(0.0593)	(0.0598)
SIZE	-0.0012***	-0.0011***	-0.0011***
	(0.0002)	(0.0002)	(0.0002)
RDS	0.0053**	0.0058***	0.0058***
	(0.0104)	(0.0089)	(0.0087)
CAPEX	0.0017*	0.0020**	0.0020**
	(0.0656)	(0.0355)	(0.0365)
TURNOVER	0.0016	0.0019	0.0019
	(0.2800)	(0.2047)	(0.2045)
SGA	-0.0200***	-0.0205***	-0.0205***
	(0.0066)	(0.0060)	(0.0059)
DMTB	-0.0913	-0.0904	-0.0902
	(0.2815)	(0.2861)	(0.2872)
INVERS_BV	0.0058**	0.0058**	0.0057**
	(0.0144)	(0.0145)	(0.0145)
CONS	0.0535***	0.0522***	0.0520***
	(0.0000)	(0.0000)	(0.0000)
N	15,742	15,742	15,742
R-sq	0.2652	0.2651	0.2651

Table 7: Restricting the sample to eight major countries

	Heckman (second-stage estimations)		
	(1)	(2)	(3)
Y02	-0.0066**		
	(0.0116)		
Y02_square	0.0071***		
	(0.0076)		
lnY02		-0.0128*	
		(0.0962)	
lnY02_sq		0.0128	
		(0.1071)	
Y02ratio			-0.0111*
			(0.0963)
Y02ratio_sq			0.0094**
			(0.0452)
IMR	-0.0161***	-0.0154***	-0.0153***
	(0.0014)	(0.0016)	(0.0017)
SLACK	-0.0068***	-0.0072***	-0.0072***
	(0.0030)	(0.0024)	(0.0024)
SCIENCE	0.0026**	0.0028**	0.0028**
	(0.0164)	(0.0227)	(0.0220)
PATME	-0.0056**	-0.0056**	-0.0056**
	(0.0275)	(0.0278)	(0.0274)
SIZE	-0.0013***	-0.0012***	-0.0012***
	(0.0007)	(0.0004)	(0.0004)
RDS	0.0065***	0.0068***	0.0068***
	(0.0001)	(0.0001)	(0.0001)
CAPEX	0.0027**	0.0029***	0.0029***
	(0.0171)	(0.0083)	(0.0083)
TURNOVER	0.0029	0.0032*	0.0032*
	(0.1054)	(0.0819)	(0.0827)
SGA	-0.0219***	-0.0222***	-0.0222***
	(0.0014)	(0.0013)	(0.0013)
DMTB	-0.0646	-0.0648	-0.0648
	(0.1531)	(0.1498)	(0.1498)
INVERS_BV	0.0054***	0.0054***	0.0054***
	(0.0022)	(0.0022)	(0.0022)
CONS	0.0468***	0.0469***	0.0468***
	(0.0000)	(0.0000)	(0.0000)
N	17,200	17,200	17,200
R-sq	0.1902	0.1901	0.1900

Table 8: Country-specific regressions

	Heckman (second-stage estimations)					
	Europe	US	Japan	Europe	US	Japan
Y02	0.1014***	0.0449	0.0039**	-0.0099	-0.0252**	-0.0040**
	(0.0036)	(0.5761)	(0.0183)	(0.1412)	(0.0167)	(0.0267)
Y02_square	-0.2637***	-0.1377	-0.0196***	0.0131	0.0312***	0.0026*
	(0.0033)	(0.5254)	(0.0025)	(0.1588)	(0.0092)	(0.0793)
Y02_cubic	0.1689***	0.1000	0.0150***			
	(0.0032)	(0.4719)	(0.0039)			
IMR	-0.0084	-0.0394***	-0.0079***	-0.0068	-0.0375***	-0.0077***
	(0.1833)	(0.0066)	(0.0084)	(0.2747)	(0.0045)	(0.0100)
SLACK	-0.0071***	-0.0068	-0.0046**	-0.0073***	-0.0069	-0.0047**
	(0.0043)	(0.1803)	(0.0152)	(0.0038)	(0.1509)	(0.0155)
SCIENCE	-0.0022	0.0069**	-0.0003	-0.0022	0.0071**	-0.0003
	(0.4449)	(0.0428)	(0.4702)	(0.4281)	(0.0331)	(0.4928)
PATME	-0.0134*	-0.0735***	-0.0026*	-0.0128*	-0.0714***	-0.0025*
	(0.0703)	(0.0062)	(0.0681)	(0.0762)	(0.0060)	(0.0704)
SIZE	-0.0020**	-0.0025*	-0.0002	-0.0018**	-0.0023*	-0.0001
	(0.0123)	(0.0512)	(0.1254)	(0.0222)	(0.0602)	(0.3505)
RDS	0.0117**	0.0020	0.0033***	0.0124**	0.0025	0.0033***
	(0.0251)	(0.5882)	(0.0000)	(0.0216)	(0.5146)	(0.0000)
CAPEX	0.0022	0.0079***	-0.0009	0.0021	0.0081***	-0.0009
	(0.2241)	(0.0039)	(0.3933)	(0.2447)	(0.0035)	(0.3631)
TURNOVER	0.0002	0.0073*	0.0032***	-0.0000	0.0071*	0.0031***
	(0.9511)	(0.0602)	(0.0000)	(0.9940)	(0.0805)	(0.0000)
SGA	-0.0276***	-0.0176***	-0.0119***	-0.0278***	-0.0182***	-0.0120***
	(0.0000)	(0.0025)	(0.0001)	(0.0000)	(0.0020)	(0.0001)
DMTB	0.1230	-0.0965	0.1397*	0.1237	-0.0965	0.1407*
	(0.1037)	(0.1250)	(0.0757)	(0.1014)	(0.1241)	(0.0757)
INVERS_BV	-0.0001	0.0152***	0.0059***	-0.0001	0.0153***	0.0060***
	(0.9546)	(0.0002)	(0.0000)	(0.9617)	(0.0001)	(0.0000)
CONS	0.0584***	0.0627***	0.0246***	0.0554***	0.0616***	0.0250***
	(0.0000)	(0.0022)	(0.0015)	(0.0000)	(0.0015)	(0.0007)
N	4710	6616	7628	4710	6616	7628
R-sq	0.3281	0.2397	0.4931	0.3265	0.2378	0.4913